April 16, 1891.

Sir WILLIAM THOMSON, D.C.L., LL.D., President, in the Chair.

The Presents received were laid on the table, and thanks ordered for them.

The following Papers were read :—

I. "On the Causes which produce the Phenomena of New Stars." By J. NORMAN LOCKYER, F.R.S. Received November 28, 1890.

(Abstract.)

In communications to the Society during the last four years, I have produced evidence to show that many so-called stars are composed of swarms of meteorites, and are increasing their temperature. Taking a normal case of an undisturbed swarm, I have shown, by means of a "temperature curve," the spectra given by the same mass of meteorites in its evolution from a nebula to a condensed and nearly cold body. In considering this question, the appearance of the so-called "New Stars" was referred to, and it was suggested that such appearances might be due to the collision of meteor-swarms or streams in space, an idea which I first put forward with regard to Nova Cygni in 1877.

It became obvious that a complete discussion of these phenomena would afford a valuable test of the general hypothesis, for the reason that such bodies, instead of going forward along the temperature curve, should go back as they cooled and became invisible.

All the observations have, therefore, been brought together and discussed from this point of view, the investigation having special reference to the sequence of spectroscopic changes from the first appearance of a new star to its final disappearance.

The various theories which have been put forward since the appearance of the new star of 1572 are referred to in the paper, and these are followed by a general statement of the meteoritic theory of the origin of new stars. The remaining part of the paper consists of a detailed discussion of all the observations of new stars which have been made, and the final result is a complete justification of the conclusion arrived at from the first survey that "new stars, whether seen in connexion with nebulæ or not, are produced by the clash of meteor-swarms." Some of the chief points may be referred to here.

The investigation has shown that there is a close relation between the spectra of comets and the spectra of new stars, but whereas in comets only one swarm has to be considered, in new stars there are two swarms which may or may not be equally dense or of equal dimensions. The spectrum of a new star is therefore a compound one. We have, in fact, a mixed radiation and absorption spectrum similar to that presented by a variable like Mira Ceti when at its maximum brilliancy. In another paper I have shown that variables of the Mira type are really double swarms, and hence the conclusion that the difference between this class of variables and new stars is only a difference in the orbits of the subsidiary swarms.

Omitting Nova (U) Orionis, which proved to be only a long period variable, only three new stars have been spectroscopically observed; namely, Nova Coronæ (1866), Nova Cygni (1876–77), and Nova Andromedæ (1885).

In Nova Coronæ, when first observed, a spectrum of bright lines was superposed upon one of dark lines. The absorption phenomena were similar to those characteristic of stars like α Orionis, and the chief radiation was that of hydrogen. A discussion of the observations suggests that two of the ill-defined lines in the blue may have been due to carbon. In the discussion of cometary phenomena which I have previously communicated to the Society, I pointed out that in many cases the blue band appeared to have two maxima, one at λ 468 and one at λ 473, and it is more than probable that the two lines of the Nova were identical with those of comets.*

In comets, the blue band, whether single or double, is generally admitted to be due to carbon, from its association with the undoubted carbon band in the green, and the same origin is therefore probable in the case of the Nova. Whatever the origin of the two lines in Nova Coronæ, the fact of their being common to comets and a new star is the point I am anxious to bring out. The F line was recorded throughout the whole period of observation, and another bright line, apparently coincident with the chief nebula line, was recorded by Messrs. Stone and Carpenter.

The suggestion that a new star is produced by the collision of two meteor-swarms or streams is fully borne out by the discussion of the observations of Nova Coronæ. The mixed phenomena of absorption and radiation which were observed are simply and sufficiently explained on this supposition. An attempt is made in the paper to

* *Note, April* 4.—The band in question is also probably identical with the one seen in some of the stars of the Wolf-Rayet type. Dr. and Mrs. Huggins have recently made observations of some of these stars which have led them to conclude that the band is not due to carbon ('Roy. Soc. Proc.,' vol. 49, p. 33). I am not yet convinced on this point, but I shall take another opportunity of replying to their remarks.

show that the spectrum of the Nova can be reproduced by integrating the spectrum of a comet at a certain temperature, and a nebula of a certain degree of condensation. The resulting spectrum differs only very slightly from that of the Nova, and the differences can be accounted for by difficulties of observation.

Nova Cygni is by far the most important new star which has appeared in spectroscopic times. Numerous observations were made, and they are, on the whole, in reasonable agreement. The most complete observations were made by Vogel. When first observed, the spectrum consisted of several bright lines and flutings, the lines of hydrogen being very conspicuous. As the star gradually faded away, there was a general diminution in the number and brightness of the lines, but the most striking feature was the *brightening* of the line in the green, near λ 500, which is generally accepted to be the nebula line, as the other lines faded. Finally, the spectrum consisted solely of the line 500. The discussion indicates that, in addition to hydrogen, there was the radiation of carbon vapour, the flutings seen being those which are most frequently observed in comets. They are, however, modified by the superposition of the spectra of other substances. Practically all the lines and flutings seen in the spectrum of Nova Cygni can be explained by reference to laboratory work at low temperatures. As in the case of Nova Coronæ, the spectrum of Nova Cygni can be reproduced by integrating the spectra of bodies which we have reason to believe are swarms of meteorites. Several examples of this are given in the paper. In the earlier stages, it is necessary to integrate the spectra of at least three swarms of different degrees of condensation, but as the spectrum became simpler, two are sufficient. The compound origin and character of the spectrum of a Nova is thus clearly indicated. It is not to be supposed from these integrations that in the first instance there are really three or more swarms engaged. A Nova is probably produced by the collision of only two swarms, but the resulting mixed swarm is so complicated that we can only represent it by assuming at least three temperature conditions. There will be the temperatures corresponding to each of the central condensations, and that corresponding to the outliers. As the swarm cools, the temperature becomes more equal throughout, and finally the swarm resembles a planetary nebula.

The spectrum of Nova Andromedæ was at no time a very striking one, and was always difficult to observe. It was also further complicated by being superposed upon the then imperfectly recognised spectrum of the Great Nebula, in which it was involved. The spectrum was almost continuous, with brighter portions here and there, which could only be measured with difficulty. Consequently, the results obtained by different observers are somewhat discordant. The discussion shows that what was really observed after the star had

faded was nothing more than the spectrum of the nebula itself, as might be expected. Owing to the difficulty of making the observations, the apparent variations of the spectrum from day to day may not be real, and it is hopeless to attempt to explain them by a reference to the effects produced by a gradual fall of temperature. As the star only fell two magnitudes during the whole period of spectroscopic observation, the change of temperature would not be so great as in Nova Cygni, and the variations would not be so well marked No lines or bands, however, were on any occasion recorded in the spectrum with which we are not familiar in other bodies which, there is evidence to show, are meteoritic swarms. A diagram shows that the spectrum of the Nova, as seen by Copeland, on October 1, can be reproduced by adding the spectrum of hydrogen to that of the nebula.

It is next pointed out that the theoretical sequence of phenomena in the spectrum of a Nova produced by the collision of two swarms of different densities is in strict accordance with the partial sequences actually observed.

A discussion of the colour phenomena shows also that in Novæ we have to deal with mixed swarms, the colours at certain stages being compound ones.

In my former paper, I have shown that carbon radiation is one of the chief characteristics of uncondensed meteor-swarms, and the discussion of the new stars has revealed the fact that carbon is also one of the chief characteristics of their spectra, though modified by other substances.

The observed changes in magnitudes of Novæ are also in accordance with the collision theory. The rapid fading away demonstrates most conclusively that small bodies, and not large ones, are in question.

The observations with which I have had to deal have often been imperfect, owing to the difficulty of observing this class of bodies, and different observers have frequently disagreed with regard to some of the spectroscopic details, but still, as I have endeavoured to show, most of the discrepancies can be reconciled when difficulties of observation are allowed for.